Set 30: Reaction Stoichiometry Part I

Skill 30.01: Be able to classify a stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass
Skill 30.02: Identify the steps required to solve each type of stoichiometry problem
Skill 30.03: Be able to identify the mole ratio between two substances in a chemical reaction

Skill 30.01: Be able to classify a stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

Skill 28.01 Concepts

The branch of chemistry that deals with the mass relationships among reactants and products in a chemical reaction is *stoichiometry*. All of the reaction-stoichiometry problems in this course can be classified as one of four types:

1. mole – mole
2. mole – mass
3. mass – mole
4. mass – mass

Each type is defined in terms what is given and what is unknown in the problem. Consider the following example:

Example

Classify the following stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

Phosphorous readily reacts with atmospheric oxygen to form diphosphorous pentaoxide as shown below:

$P_4 + 5O_2 \rightarrow 2P_2O_5$

If 2.0 g of phosphorous react with excess oxygen, how much in moles of diphosphorous pentaoxide can be produced.

Solution

In the problem you are *given* the mass of phosphorous (P_4): 2.0 g
You are asked to find the moles of diphosphorous pentaoxide (P_2O_5): ? moles
Therefore this is a mass-mole problem.

Skill 30.01 Problem 1

Classify the following stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

Atmospheric oxygen reacts with nitrogen in automobile engines to produce NO, a poisonous greenhouse gas

$O_2 + N_2 \rightarrow 2NO$

If 5 moles of nitrogen react, how much oxygen gas in moles is consumed?

Skill 30.01 Problem 2

Classify the following stoichiometry problem as one of the following types: mole-mole, mole-mass, mass-mole, mass-mass

In the lower atmosphere where we live, NO and UV light catalyze the production, O_3 from O_2 as shown,

$3O_2 \rightarrow 2O_3$

If 5 moles of oxygen react, how much in grams of ozone is produced?

Skill 30.02: Identify the steps required to solve each type of stoichiometry problem

Skill 30.02 Concepts

Once the stoichiometry problem has been classified, the steps required to solve the problem must be identified. Figure 1 summarizes the four types of stoichiometry problems along with steps required to solve them:

Figure 1. Steps for solving the four types of stoichiometry problems

Type	Description	Steps
mole –mole	In *mole-mole* problem, you are given the moles of one substance and asked to calculate the moles of another substance in the chemical reaction.	moles given → moles unknown
mole-mass	In a *mole-mass* problem, you are given the moles of one substance and asked to find the mass of another substance in the chemical reaction	moles given → moles unknown → mass unknown
mass – mole	In a *mass-mole* problem, you are given the mass of one substance and asked to find the moles of another substance in the chemical reaction	mass given → moles given → moles unknown
mass –mass	In a *mass-mass* problem, you are given the mass of one substance and asked to find the mass of another in the chemical reaction	mass given → moles given → moles unknown → mass unknown

Skill 30.02 Problem 1

Identify the steps required to solve the problem below:

In the lower atmosphere where we live, NO and UV light catalyze the production, O_3 from O_2 as shown,

$3O_2 \rightarrow 2O_3$

If 500.0 g of oxygen react, how much in grams of ozone is produced?

Skill 30.03: Be able to identify the mole ratio between two substances in a chemical reaction

Skill 30.03 Concepts

Each of the four types of stoichiometry problems require the use of a mole ratio. The mole ratio is the conversion factor that relates the number of moles of any two substances in a chemical reaction. Consider for example the chemical equation for the electrolysis of aluminum oxide to produce aluminum and oxygen:

$2Al_2O_3 \rightarrow 4Al + 3O_2$

According to this reaction,

2 moles of Al_2O_3 yields 4 moles of Al and 3 moles of O_2

In other words,

There are 2 moles of Al_2O_3 for every 4 moles of Al = $\frac{2 \text{ mole } Al_2O_3}{4 \text{ mole Al}}$ *or* $\frac{4 \text{ mole Al}}{2 \text{ mole } Al_2O_3}$

There are 2 moles of Al_2O_3 for every 3 moles of O_2 = $\frac{2 \text{ mole } Al_2O_3}{3 \text{ mole } O_2}$ *or* $\frac{3 \text{ mole } O_2}{2 \text{ mole } Al_2O_3}$

There are 4 moles of Al for every 3 moles of O_2 = $\frac{4 \text{ mole Al}}{3 \text{ mole } O_2}$ *or* $\frac{3 \text{ mole } O_2}{4 \text{ mole Al}}$

Skill 30.03 Problem 1

For each of the problems below:

(a) Balance the reaction
(b) Classify the problem as: mole-mole, mass-mole, mole-mass, or mass-mass
(c) Identify the mole ratio between the unknown and the given substances

Item	Problem	Classification	Mole ratio
1	What mass in grams of 1-chloropropane (C_3H_7Cl) is produced if 400. g of propane react with excess chlorine gas according to the equation ___C_3H_8 + ___Cl_2 → ___C_3H_7Cl + ___HCl		
2	How many grams of chlorine gas are required to react completely with 10.00 grams of sodium? ___Cl_2 + ___Na → ___NaCl		
3	The Haber process for process for producing ammonia commercially is represented by the equation below. To completely convert 9.0 mol hydrogen gas to ammonia gas, how many moles of nitrogen gas are required? ___N_2 + ___H_2 → ___NH_3		
4	How much sodium acetate, in grams, can be produced from 2.5 grams of sodium bicarbonate and excess acetic acid ($HC_2H_3O_2$)? ___$HC_2H_3O_2$ + ___$NaHCO_3$ →___$NaC_2H_3O_2$ + ___CO_2 + ___H_2O		
5	How much oxygen, in moles, can be produced from 3.0 grams of potassium chlorate? ___$KClO_3$ → ___KCl + ___O_2		